

Article

Firm ESG Performance and Supply-Chain Total-Factor Productivity

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Abstract: Promoting firms' green evolution and achieving sustainable, high-quality development have become crucial for firms' sustainability. This study uses data from publicly listed automotive manufacturing firms from 2009 to 2022 to examine the impact of target firms' environmental, social, and governance (ESG) performance on total-factor productivity (TFP) at upstream and downstream firms from a supply-chain perspective. By employing a two-way, fixed-effects model, mediation analysis, and a moderation model, the study provides comprehensive insights. The findings reveal the following: (1) The ESG performance of target firms in automotive manufacturing significantly improves the TFP of downstream customers, and this conclusion is robust even when using instrumental variable methods, additional control variables, and rigorous robustness tests. (2) Mechanism analysis indicates that the ESG performance of target firms alleviates the financing constraints of their customers, thereby positively impacting the customers' TFP. Additionally, the study finds that the monopolistic power of the target firm negatively moderates the relationship between its ESG performance and the TFP of its customers. These empirical findings enhance the understanding of supply-chain spillover effects and provide a new theoretical foundation for improving firms' ESG performance.

Keywords: ESG performance; total-factor productivity; financing constraints; monopolistic advantage



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1. Introduction

In recent years, global manufacturing has driven the extensive adoption of supply chain management in the manufacturing industry, introducing a new management paradigm. The 20th National Congress of the Communist Party of China stressed the necessity of strengthening the resilience and security of China's industrial and supply chains. Enhancing the resilience and security of critical industrial and supply chains has become a national priority in many countries. Improving the resilience and security of the supply chain requires continuous advancements in its stability, sustainability, and digital transformation, as well as optimizing resource allocation efficiency across various upstream and downstream segments. Due to the inherent symbiotic relationship between suppliers and customers, an economic interdependence characterized by “prosper together, suffer together” arises. The business outlook of key customers has a significant impact on the operational decisions of their suppliers. Conversely, involving supplier firms in new product development can boost customers' product innovation and financial returns. Therefore, conducting in-depth research on the forward and backward linkages of the supply chain is crucial for enhancing the resilience and security of industrial supply chains.

Environmental, social, and governance (ESG) performance is recognized as a non-financial metric that is a key measure of sustainability for global firms, and it helps build their future competitive advantage. While the substantial initial costs associated with ESG implementation may adversely affect a firm's performance [1], the long-term benefits and

strategic value of ESG initiatives make them a promising area for investment. This potential is increasingly recognized, as the positive impact of firms' ESG practices has become a focal point of discussion within the academic community. Studies have shown that ESG performance improves financial performance [2,3], reduces specific operational risks [4], enhances firm profitability [5], increases firm value [6,7], and improves firm performance across all life-cycle stages [8]. However, an ongoing debate persists over whether ESG performance is merely superficial or truly effective [9]. Some studies, such as those examining Indian firms, have found that ESG practices can reduce firm performance [10]. Additionally, firm greenwashing can harm consumer interests and trigger a crisis of public trust [11]. These concerns have prompted scholars to reassess the impact of ESG performance. These studies have played a key role in clarifying and exploring the externalities of firm ESG performance. However, a comprehensive understanding of how firm ESG performance impacts supply chains remains elusive. Regarding supply-chain contagion, the existing literature suggests that the risks and price volatility experienced at target firms are transmitted to their suppliers and customers through contagion effects, necessitating collaborative management between upstream and downstream firms to mitigate risks and stabilize volatility. Does supply-chain contagion also include positive spillovers? The existing literature has shown that better ESG performance can provide numerous advantages to firms, such as long-term value, an enhanced social reputation, and improved access to financing [2,7,8]. This study considers the significant ESG spillovers of firms and examines whether target firms can transfer these spillovers to their suppliers, as well as their customers along the supply chain.

Productivity is often seen as the "surplus" in total output that cannot be explained by factor inputs, known as total-factor productivity (TFP). TFP measures the overall efficiency with which inputs are converted into outputs, considering all factors of production [12]. Studies indicate that greater openness, trade orientation, human capital, technological progress, efficient factor allocation, and scale efficiency can significantly enhance a firm's TFP. These factors improve resource allocation, optimize labor and capital usage, foster innovation, and expand market reach [13,14]. Additionally, strategies including environmental regulation and tax management can indirectly boost TFP by creating a favorable business environment and reducing unnecessary costs and risks [15,16]. Recently, research has focused on how ESG performance can improve TFP. Firms with strong ESG performance excel in environmental protection, social responsibility, and governance practices, which can enhance brand value, attract investment, and increase market confidence, ultimately boosting TFP [3,5]. Based on firms' green supply chain management theory, this study hypothesizes that a firm's ESG performance can enhance supply-chain spillovers. This implies that the positive effects of good ESG performance extend beyond the firm itself, benefiting its suppliers and customers. To test this hypothesis, a multidimensional fixed-effects OLS model was used to analyze the impact of a firm's ESG performance on the TFP of its suppliers and customers. This analysis provides insights into how ESG performance influences the supply chain and aids in formulating strategies to enhance overall supply-chain efficiency.

Compared to the existing literature, this study presents three significant innovations. First, this study fills a research gap regarding the role of ESG performance at the supply-chain level. Current ESG studies primarily focus on the positive impacts of ESG performance on the firms themselves [2,4,6], often neglecting its externalities on the supply chain. Specifically, there is a lack of research examining how a firm's ESG performance affects other firms within the supply chain. This study aims to bridge this gap and enhance the understanding of the economic impact of ESG performance. Second, in terms of the object under study, this study innovatively analyzes how a firm's ESG performance affects the TFP of its suppliers through backward linkages within the supply chain. This analysis not only reveals the specific impacts of ESG performance on upstream firms but also uncovers the potential mechanisms through which ESG performance contributes to the resilience of the industrial supply chain. Third, this study makes an important contribution in terms of mechanism analysis. This study investigates how a firm's ESG performance alleviates

the financing constraints of suppliers in the supply chain, thereby increasing their TFP. Through this mechanism analysis, the study highlights how ESG performance improves the financing environment for supply-chain firms and explains how these improvements translate into productivity gains. Overall, this study provides new perspectives and deep academic contributions to understanding the impact of ESG performance on the supply chain by filling existing research gaps, clearly defining the objects of study, and analyzing specific mechanisms.

2. Mechanisms and Hypotheses

2.1. ESG Performance and Supply-Chain TFP

The relationship between suppliers and customers is typically established through explicit economic contract arrangements, creating a supply-chain connection between them [17]. This connection facilitates the flow of information, knowledge, personnel, and logistics across the supply chain [18]. From a supply-chain positioning perspective, suppliers must respond to and meet the core needs of their customers [19]. However, when customers face upstream suppliers with monopolistic power, they may be forced to accept the supplier's product structure and market arrangements [20]. Regardless of an unequal dependency between the supplier and customer, in economics, the sole purpose of business operations is profit maximization [21], and both suppliers and customers collaborate to achieve this goal. However, with an increasing focus on sustainability, the emergence of ESG principles is challenging the traditional theories of profit maximization [21], leading to a more holistic assessment of firm performance that considers a broader range of stakeholders and aligns with the sustainable development goals (SDGs) [22,23]. This raises an important question: as firms prioritize ESG factors, will this negatively impact their TFP? This concern warrants careful consideration because improving TFP is crucial for firms to maximize profits more efficiently.

The existing literature indicates that good ESG performance can enhance a firm's TFP. From an environmental perspective, strong ESG performance helps reduce compliance costs related to environmental and social regulations, lowering operating costs and improving efficiency [3]. From a social-performance angle, good ESG practices can enhance a company's reputation [24], allowing it to build strong relationships with key resource providers, such as governments and banks [25,26], and thereby improving external communication efficiency. In terms of governance, good ESG performance can reduce conflicts of interest between management and shareholders [27], thus enhancing internal efficiency. By improving operational, external, and internal efficiencies through good ESG practices, firms can boost overall TFP.

Juan (2016) analyzed the upstream productivity spillover from customers to suppliers, finding that customers' productivity significantly affects suppliers through an "endogenous channel", making it the most important source of spillover in the supply chain [28]. This aligns with vertical spillover theory [29], which posits that externalities like ESG benefits are transmitted along the supply chain through the flow of information, knowledge, personnel, and logistics [30,31], leading to productivity gains for both suppliers and customers [32]. Furthermore, in supply-chain finance, firms with strong ESG performance benefit from higher long-term value assessments [7,33], avoiding environmental costs and sending positive credit signals [25,26], which alleviates financing constraints. Through the supply chain, suppliers and customers benefit from the positive externalities of the target firm's ESG performance, reducing their credit constraints, lowering communication costs, and increasing investment in innovation while thereby enhancing TFP.

Although ESG challenges the traditional profit maximization theory, it can still enhance operational, external, and internal efficiencies through good practices, thereby boosting overall TFP. Drawing from vertical spillover theory [29], the target firm's ESG performance reduces credit constraints for suppliers and customers, lowers communication costs, and increases investment in innovation, ultimately enhancing their TFP. Based on this, the following hypotheses were proposed.

H1a: *The superior ESG performance of the target firm enhances the TFP of suppliers in the supply chain.*

H1b: *The superior ESG performance of the target firm enhances the TFP of customers in the supply chain.*

2.2. ESG Performance and Financing Constraints in the Supply Chain

The superior ESG performance of a firm can alleviate financing constraints for suppliers and customers within the supply chain through contagion effects. First, as a positive signal, ESG performance enhances the firm's visibility and reputation with banks, the public, and government entities [25,26], extending its influence to suppliers and customers in the supply chain and thereby enhancing their borrowing capacity while alleviating financing constraints [8]. Second, superior ESG performance fosters firm value [7,33], which increases the value of suppliers and customers in the supply chain through the contagion effect. Improved firm value translates into higher shareholder perceptions of long-term firm value, more procurement contracts, increased market recognition [34], and enhanced competitiveness [35], thus increasing the long-term value and market competitiveness of suppliers and customers within the supply chain. Third, ESG performance optimizes the financing environment and reduces the financing constraints of suppliers and customers in the supply chain through contagion effects by avoiding high operating costs and financial constraints while effectively managing environment-related risks. By committing to environmental and social concerns, firms adopt superior ESG performance, which helps reduce not only their own financing constraints but also those of their suppliers and customers within their supply chains, all within the framework of the equator principles. Given these considerations, the following hypotheses were proposed.

H2a: *The superior ESG performance of target firms alleviates the financing constraints of suppliers within the supply chain.*

H2b: *The superior ESG performance of target firms alleviates the financing constraints of customers within the supply chain.*

2.3. Moderating Effect of Monopoly Power on the Relationship between ESG Performance and Firm TFP

Existing references support the argument that monopolistic power hinders both long-term profit maximization (due to inefficiency and complacency) and Pareto efficiency (due to the misallocation of resources and deadweight loss) [36,37]. This brings up the question of whether monopolistic power could hinder the positive externalities generated by target firms.

Smirllok (1985) supported the efficiency hypothesis, arguing that market share represents efficiency [38]. When there is a significant positive correlation between market share and profitability, the efficiency hypothesis is supported. However, Shepherd (1986) criticized the idea of equating efficiency with market power, proposing the relative market power (RMP) hypothesis, which defines market power as stemming from a firm's dominance in a specific market [36]. The quiet life hypothesis (Hicks, 1935) aligns with Shepherd's RMP view, suggesting that firms with substantial market share pay less attention to efficiency, as they can leverage their market power to set prices and secure profits automatically [37]. According to Shepherd's RMP hypothesis and Hicks's quiet life hypothesis, firms with stronger monopoly power are less focused on efficiency and are more likely to suppress green technological innovation, thereby hindering the positive spillover effects of good ESG performance within the supply chain [39].

Furthermore, monopolistic firms disrupt the collaborative goal of maximizing profits through improved TFP within the supply chain. They become less inclined to share new technologies and information with suppliers and customers, weakening the vertical

spillover effects across the entire supply chain [40]. Strong monopoly power in target firms can stifle green innovation and negate the positive impact of ESG performance in easing financing constraints, which would otherwise foster innovation within the supply chain [41,42].

Building on Shepherd's RMP hypothesis and Hicks's quiet life hypothesis, monopoly power undermines vertical spillover effects within the supply chain and inhibits innovation, thereby negatively moderating the relationship between a target firm's ESG performance and the TFP of its suppliers and customers. Based on this, the study proposed the following hypotheses.

H3a: *The stronger the monopolistic power of the target firm, the weaker the positive impact of its ESG performance on the TFP of suppliers within the supply chain.*

H3b: *The stronger the monopolistic power of the target firm, the weaker the positive impact of its ESG performance on the TFP of customers within the supply chain.*

3. Methodology and Data

3.1. Empirical Model and Variables

This study explored the impact of a target firm's ESG practices on the TFP of upstream and downstream firms in the automotive manufacturing sector, highlighting the broader implications of ESG performance on the efficiency of the entire supply chain. According to the Hausman test, the two-way fixed-effects OLS model was considered appropriate for this study. Therefore, the two-way fixed-effects OLS model was selected as the baseline regression model in this study, as shown in Equation (1):

$$TFPLPS_{pt} = \beta_{0s} + \beta_{1s} \times ESG_{pt} + \lambda X_{pt} + \lambda_p + \eta_t + \varepsilon_{pt} \quad (1)$$

$$TFPLPC_{pt} = \beta_{0c} + \beta_{1c} \times ESG_{pt} + \lambda X_{pt} + \lambda_p + \eta_t + \varepsilon_{pt} \quad (2)$$

To ensure that the results would be useful, this study examined the upstream and downstream effects in different regressions using basic regression. In Equation (1), $TFPLPS_{pt}$ represents the TFP of a supplier of the target firm, and it is a dependent variable. In Equation (2), $TFPLPC_{pt}$ represents the TFP of a customer of the target firm, and it is a dependent variable. This study calculated TFP on a firm-specific basis within the automotive manufacturing sector. ESG_{pt} denotes the ESG performance of the target firm, and it is the independent variable. X_{pt} comprises control variables at the level of upstream or downstream firms of the target firm. λ_p denotes province-fixed effects, and η_t displays year-fixed effects. This study controlled for province-, industry-, and time-specific effects. ε_{pt} is the error term, capturing unobserved random factors. This model served to investigate how a target firm's ESG behavior affects the TFP of its upstream and downstream firms while controlling for province- and time-specific effects, as well as other relevant variables.

3.2. Descriptive Statistics

3.2.1. Dependent Variable

The dependent variable in this study was the TFP of suppliers and customers of targeted listed firms. The study calculated supply-chain efficiency based on supply-chain relationships, using the improvement in the TFP of suppliers and customers to represent the enhancement of supply-chain efficiency, and vice versa. The study employed industry-fixed effects in the baseline regression model to mitigate biases that vary by industry but not over time. This control helps isolate the effects of interest from industry-specific variations unrelated to the study's focus on supply-chain dynamics and productivity. Productivity growth itself can be decomposed into technological progress and improvements in technological efficiency [43], with TFP representing the economic growth resulting from technological progress based on the C-D production function. Therefore, a firm's TFP is positively correlated with its technological progress. Common methods for calculat-

ing a firm's TFP in current research include the OLS, FE, LP [44], and OP methods [45]. Compared with the FE and OLS methods, the LP and OP methods are more effective at overcoming the issues of input-factor endogeneity and sample selectivity. Furthermore, the advantage of the OP method over the LP method lies in its ability to address the issue of negative investment variables while also enhancing the sensitivity of its relationship with productivity. Therefore, this study used the OP method in its baseline regression to calculate the TFP of suppliers and customers in the primary supply chain of the target firms. In the robustness analysis, the LP and OLS methods were used to replace the OP method in order to verify the robustness of the baseline regression results. This study calculated TFP at the firm level. Intermediate inputs refer to the total of a firm's operating expenses, sales amount, management fee, and financial expenses, minus depreciation and cash payments to employees. Capital input is defined as the net value of the firm's fixed assets, labor input is the total number of employees in the firm, and the total output is the firm's operating revenue. Since the suppliers and customers are also listed firms, the data for calculating their TFP were sourced from the China Stock Market & Accounting Research Database (CSMAR). The specific measures and principles of the OLS, FE, LP, and OP methods are shown in Table 1.

Table 1. Calculation methods and principles of common TFPs.

Methodology	Variable Name	Principle
Least squares method (OLS)	TFP-OLS	Estimating the residuals of the C-D production function using least squares estimation
Fixed-effects method (FE)	TFP-FE	Estimating the residuals of the C-D production function using individual fixed-effects regression
Olley–Pakes method (OP)	TFP-OP	Based on the consistent semiparametric estimator approach, the logarithmic value of the residuals is obtained by calculating the capital stock coefficients using a nonlinear least squares method, and finally fitting the C-D production function
Levinsohn–Petrin method (LP)	TFP-LP	On the basis of the OP method, the proxy variable for investment is replaced with an indicator of intermediate goods inputs from the amount of investment, and finally, the C-D production function is fitted to obtain the logarithmic value of the residuals

3.2.2. Core Explanatory Variable

The core explanatory variable in this study is the ESG rating of the target firms, all of which operate within the manufacturing sector. As the focus on SDGs shifts from the national and societal levels to firms, more firms are facing external pressure to voluntarily disclose ESG reports and related information. Third-party rating agencies also publish ESG reports and information based on ESG standards. These ESG ratings provide crucial information about a firm's sustainability performance and social responsibility. Investors and stakeholders are increasingly considering a firm's ESG performance in their investment and business decisions. Consequently, ESG ratings have become essential tools for assessing firm sustainability and social responsibility, guiding firms toward environmentally friendly and transparent business practices.

Huazheng ESG assessment data are widely used in existing research [46]. This study assigned values to the Huazheng ESG rating data of the firms, sourced from the Wind Financial Terminal. The methodology for handling the core explanatory variable of this

study followed these steps: First, the ESG ratings for the four quarters were sorted in descending order, ranging from C, CC, CCC, B, BB, BBB, A, and AA to AAA. Next, the ratings were assigned numerical values from 1 to 9, with higher values indicating better ESG ratings. Finally, the average rating across the four quarters was used to determine the annual ESG scores of the firms, establishing the core explanatory variable of this study.

3.2.3. Mechanism Variable

Based on the measurement ideas of Fee et al. [47] and Hadlock and Pierce [48], this study calculated the financial constraint (FC) index to measure the degree of financing constraints of firms, and the larger the value of the FC index, the more severe the degree of financing constraints of firms. The methodology for calculating the FC index is detailed below. First, firms' size, age, and cash dividend payout ratio were standardized annually. The standardized mean values determined the financing constraint dummy variable, QUFC, with values set to 0 for firms above the upper-quartile threshold and 1 for those below the lower-quartile threshold. Second, a Logit model was employed to estimate the probability of financing constraints occurring annually, defining the FC index, which ranged between 0 and 1. Higher FC index values indicate more severe financing constraints within firms. Key variables in the model include cash dividends declared (CASHDIV), total assets (TAs), net working capital (NWC), and earnings before interest and taxes (EBIT).

$$P(QUFC = 1|Z_{i,t}) = e^{z_{i,t}} / (1 + e^{z_{i,t}}) \quad (3)$$

$$z_{i,t} = \alpha_0 + \alpha_1 size_{it} + \alpha_2 lev_{it} + \alpha_3 (CASHDIV/TA)_{it} + \alpha_4 MB_{it} + \alpha_5 (NWC/TA)_{it} + \alpha_6 (EBIT/TA)_{it} \quad (4)$$

3.2.4. Moderator Variable

Regarding the measurement of competition intensity, most studies opt for the Herfindahl–Hirschman Index (HHI) [49]. Consequently, this study also used the HHI to assess market competition intensity, reflecting the degree of monopoly power. The larger the value of the HHI, the higher the degree of monopoly power.

$$HHI = \sum \left(\frac{X_i}{X} \right)^2 \quad (5)$$

Among them, X_i is the business income of a single firm, X is the total business income of the industry to which the firm belongs, and X_i/X indicates the market share of the target firm within the automotive manufacturing industry. The HHI index is the square of the ratio of each firm's business income within the industry to the total business income of the industry. A lower value indicates more intense competition among firms in the industry and higher market competition intensity. Conversely, a higher value suggests weaker market competition, with the market share controlled by a few large firms. To facilitate analysis, this study applied a reciprocal transformation for which a larger value reflects greater market competition intensity.

3.2.5. Control Variables

To mitigate potential biases from omitted variables and enhance the robustness of our findings, this study incorporated several control variables based on insights from Fisman and Wang [50] and Pittman and Fortin [51]. "Size" reflects the scale of suppliers and customers, measured using the logarithm of listed firms' employee numbers. "Grow" denotes the growth rate of suppliers and customers' main business income. "Tobinq" indicates Tobin's Q, reflecting the firms' long-term value. "Cflow" represents the cash flow level, calculated as the net cash flow from operating activities divided by the total assets. "Roa" measures profitability, expressed as a return on total assets. "Lev" indicates leverage, measured using the ratio of liabilities to total assets. "Capital" illustrates capital intensity, represented by the ratio of capital input to output. "Soe" characterizes property rights,

distinguishing state-owned firms. “Sepe” signifies the separation of ownership and control rights. Details on variable measurement and literature sources are provided in Table 2.

Table 2. Measurement and sources of core variables.

Variables	Types of Variables	Measurements	Literature Supporting
TFP-LP	explanatory variable	Levinsohn–Petrin Method	Levinsohn and Petrin [44]
ESG	core explanatory variable	Huazheng ESG rate	Lin, Fu and Fu [46]
grow	control variables	the growth rate of main business income	Fisman and Wang [50] and Pittman and Fortin [51]
tobinq		Tobin’s Q value	
cflow		the ratio of net cash flow from operating activities to total assets	
roa		the return on total assets	
lev		the ratio of liabilities to total assets	
soe		nature of ownership	
sepe		the separation of two rights of suppliers and customers	
FC	mechanism variable	FC	Fee, Hadlock and Pierce [47,48]
HHI	moderator variable	HHI	Ellison and Glaeser [49]

In this study, when calculating the TFP of suppliers and customers, efforts were made to control for factors that could potentially influence changes in their TFP. This approach facilitates the clearer observation and impact of supply-chain contagion effects. Control variables were derived from the CSMAR database. These variables played a crucial role in the study by mitigating interference from other factors and facilitating a more precise examination of the impact of ESG performance on the TFP of suppliers and customers within the supply chain. Adding these control variables in the baseline regression effectively avoids omitted variable bias. This study aimed to bolster the credibility and reliability of the research findings and draw more accurate conclusions. These variables served a moderating and controlling function in the study, ensuring the robustness and reliability of research outcomes.

To identify upstream and downstream firms in the industrial chain, observations of the target listed firms’ suppliers and customers are based on existing sales and procurement transactions. Following methodologies from Benton and Maloni [52] and Yang, et al. [53], this study constructs a dataset of target listed firms–clients/suppliers–year. For example, if the target listed firm (A) corresponds to multiple customers/suppliers (X/Y) in the same year (2018), observations of A-X-2018 and A-Y-2018 are constructed.

Information on the top five customer firms and top five supplier firms of A-share-listed firms was obtained from the CSMAR database. The study sample includes only cases in which the target listed firms and their customers and suppliers are all listed firms. During the sample sorting process, firms labeled as special treatment (ST) particular special treatment (*ST) and Particular Transfer (PT), along with samples with significant missing financial data, were excluded. To minimize the impact of extreme values, all continuous variables in the baseline regression were Winsorized by trimming the outliers at the 1st and 99th percentiles. Recognizing that each industry has its own unique cost structures and market dynamics, this study focused specifically on the automotive manufacturing sector to explore its TFP. The automotive manufacturing industry is categorized as “C36” by the China Securities Regulatory Commission. This study constructed two unbalanced

panel datasets based on the classification of target firms in the automotive manufacturing industry as either suppliers or customers, covering the period from 2009 to 2022. The year 2009 was chosen as the starting point for the analysis primarily because Huazheng began disclosing ESG rating data in that year. The descriptive statistics for the variables are presented in Table 3.

Table 3. Descriptive statistics.

	(1)	(2)	(3)	(4)	(5)
Variables-Supplier	N	Mean	SD	Min	Max
TFP-OP	93	7.860	0.737	6.138	9.260
ESG	93	3.917	0.956	2.500	6
size_1	93	0.157	0.321	−0.443	1.691
grow_1	93	1.487	0.585	0.938	4.633
tobinq_1	93	0.0559	0.0703	−0.0996	0.201
cflow_1	93	0.0350	0.0531	−0.104	0.156
roa_1	93	0.543	0.160	0.0959	0.785
lev_1	93	0.538	0.501	0	1
soe_1	93	7.860	0.737	6.138	9.260
sepe_1	93	3.917	0.956	2.500	6
Variables-Customer	N	Mean	SD	Min	Max
TFP-OP	93	7.476	0.843	5.080	8.803
ESG	93	4	0.749	2	6
size_1	93	0.149	0.452	−0.309	4.078
grow_1	93	1.513	0.800	0.699	5.717
tobinq_1	93	0.0601	0.0634	−0.0477	0.371
cflow_1	93	0.0425	0.0601	−0.0601	0.305
roa_1	93	0.492	0.142	0.145	0.750
lev_1	93	0.344	0.478	0	1
soe_1	93	7.476	0.843	5.080	8.803
sepe_1	93	4	0.749	2	6

Notes: SD means standard deviation; N means number of observations.

4. Empirical Results

4.1. Baseline Results

This study employed a two-way, fixed-effects OLS model as the baseline regression, with the empirical results displayed in Table 4. Column (1) shows the regression for the suppliers of target firms, while Column (2) presents the regression for the customers of target firms. Both models control for year- and province-fixed effects but do not include control variables. The regression results are significant for suppliers in Column (2) but not for customers in Column (1). Columns (3) and (4) add firm-specific variables for the suppliers and customers of the target listed firms to the models in Columns (1) and (2), respectively. The regression coefficient in Column (4) is significantly positive at the 10% confidence level, while Column (3) remains insignificant. This suggests that the ESG performance of target firms positively affects the TFP of their customer but does not significantly impact the TFP of their supplier. Specifically, the coefficient estimate in Column (3) is 0.2361, indicating that each unit increase in the ESG rating of a target firm increases the TFP of its suppliers by 0.2361, supporting H1b. This finding implies that the superior ESG performance of target listed firms generates a positive spillover

effect on downstream firms, improving the TFP of customers through forward linkages in the automotive manufacturing supply chain. The automotive industry often operates on forward linkages, where downstream firms rely heavily on the technology, components, and processes supplied by upstream manufacturers. When an upstream firm improves its ESG performance, such as through better resource efficiency, waste reduction, or employee management, it can reduce costs and enhance product quality. These improvements directly benefit downstream firms, as they receive higher-quality inputs or services, thereby increasing their TFP.

Table 4. Baseline estimation.

Variables	(1) Supplier TFP-OP	(2) Customer TFP-OP	(3) Supplier TFP-OP	(4) Customer TFP-OP
ESG	−0.0018 (0.0341)	0.4491 ** (0.2003)	0.0179 (0.0324)	0.2361 * (0.1308)
grow_1			−0.0389 (0.1891)	−0.2591 * (0.1534)
tobinq_1			−0.2236 * (0.1260)	−0.2690 ** (0.1026)
cflow_1			1.2527 (0.8340)	2.0559 (1.3436)
roa_1			4.0549 ** (1.8011)	5.9543 ** (2.3738)
lev_1			2.9088 *** (1.0865)	4.9567 *** (1.3364)
soe_1			0.0053 (0.1198)	0.3137 (0.3795)
sepe_1			−0.0000 (0.0145)	0.0264 (0.0202)
Constant	9.9438 *** (0.1399)	7.5966 *** (0.7994)	6.3308 *** (0.5912)	3.9631 *** (0.7332)
Observations	93	93	93	93
Province FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Notes: ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively, with standard robust errors in parentheses.

4.2. Mechanism Analysis

4.2.1. Mediation Effect Test

This study examined whether alleviating financing constraints is an effective mechanism through which a target firm's ESG performance enhances the TFP of its suppliers and customers. The FC index, which is based on internal cash flow and financing needs, was used to assess the impact of the target firm's ESG performance on the financing constraints of its suppliers and customers. The regression results in Column (2) of Table 5 show that the FC index for customers is significantly negative at the 10% confidence level, whereas the FC index for suppliers in Column (1) is not significant. This indicates that the target firm's ESG performance effectively alleviates the financing constraints of its suppliers, supporting H2b. The target firm projects a positive image and potential long-term firm value to the external environment, similar to a "halo effect", which then permeates to its

customers through a contagion effect. Furthermore, by demonstrating a commitment to environmental and social issues through ESG performance, the firm can not only reduce its own financing constraints but also help alleviate those of its suppliers within the framework of the equator principles. The validation of H2b highlights that the target firm's superior ESG performance can ease the financing constraints of its customers within the supply chain. The regression results presented in Table 5 provide strong evidence supporting the role of the equator principles in mitigating suppliers' financing constraints.

Table 5. Mediation effect and moderating effect test.

Variables	(1)	(2)	(3)	(4)
	Supplier FC	Customer FC	Supplier TFP-OP	Customer TFP-OP
ESG	0.0114 (0.0083)	−0.1004 * (0.0504)	0.2044 (0.2460)	3.3267 ** (1.5255)
HHI_C			0.0000 (0.0000)	48.2821 * (24.8568)
c.esg#c.HHI_C			−0.6664 (0.8799)	−10.7514 * (5.9233)
grow_1	0.0267 * (0.0153)	0.0156 (0.0202)	0.0286 (0.0192)	0.0030 (0.0079)
tobinq_1	0.0146 (0.0091)	−0.0227 *** (0.0070)	−0.2141 *** (0.0411)	0.0755 *** (0.0225)
cflow_1	−0.3377 *** (0.0856)	−0.0780 (0.1274)	1.6743 *** (0.4076)	−0.5007 (0.3726)
roa_1	−0.1549 (0.1097)	−0.3032 (0.2131)	1.9872 *** (0.6689)	3.8596 *** (0.6338)
lev_1	−0.9216 *** (0.0408)	−0.8476 *** (0.0683)	2.4074 *** (0.1989)	1.9294 *** (0.2618)
soe_1	−0.0011 (0.0110)	−0.0805 *** (0.0222)	0.0187 (0.0584)	0.4438 *** (0.0906)
sepe_1	−0.0005 (0.0006)	−0.0021 ** (0.0009)	−0.0025 (0.0030)	−0.0001 (0.0043)
Constant	0.7015 *** (0.1310)	0.6062 *** (0.2179)	6.2119 *** (0.6327)	−4.8226 (6.3430)
Observations	93	93	93	93
Province FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Notes: ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively, with standard robust errors in parentheses.

4.2.2. Moderating Effect Testing

Previous theoretical analyses suggest that monopoly power negatively moderates the relationship between a target firm's ESG performance and the TFP of its suppliers and customers [39]. As the concentration of monopoly power within the target firm increases, it is expected to hinder the transmission of ESG performance effects within the supply chain, thereby reducing the firm's ability to enhance the TFP of its suppliers and customers. To empirically test this moderating effect, this study introduces an interaction term between the target firm's ESG performance and monopoly power (measured using the Herfindahl–

Hirschman Index, HHI) into the regression model, as shown in Columns (3) and (4) of Table 5.

The results in Column (4) of Table 5 indicate that the coefficient of the interaction term between the target firm's ESG performance and monopoly power is significantly negative. This suggests that an increase in monopoly power indeed weakens the positive impact of the target firm's ESG performance on the TFP of its customers. However, the coefficient of the interaction term in Column (3) is not significant. Fundamentally, when the target firm holds a monopolistic position, the positive influence of its ESG performance on the TFP of customers diminishes. This finding aligns with the theoretical foundation, indicating that monopoly power disrupts the transmission effect of ESG performance within the supply chain, thereby weakening its positive impact on customers' TFP, which supports hypothesis H3b.

Thus, considering monopoly power becomes crucial, as it may limit the impact of ESG performance on supply-chain efficiency. In summary, the results from the moderation-effect mechanism test provide empirical evidence supporting the negative moderating role of monopoly power in the relationship between the target firm's ESG performance and supply-chain efficiency. This underscores the importance of accounting for monopoly dynamics when understanding the nuanced interactions between ESG performance and supply-chain dynamics. This highlights the significance of monopoly power as a moderating factor in the relationship between a target firm's ESG performance and supply-chain efficiency. By empirically demonstrating the weakening effect of monopoly power on the positive influence of ESG performance, this study reveals the complex dynamics within the supply chain, thereby enriching our understanding of the broader impacts of ESG factors.

4.3. Endogenous Tests

4.3.1. Instrumental Variable Two-Stage Least Square (IV-2SLS)

To address potential endogeneity issues arising from unobserved variables and reverse causality between company ESG performance and TFP, this study utilized the IV-2SLS method. Following Rahman, et al. [54], the instrumental variables used were the average score of the local prefecture-level city, denoted as "esgiv2". IV-2SLS was then applied to resolve endogeneity concerns, with detailed results presented in Table 6. The IV-2SLS approach aims to address potential endogeneity by using industry-average ESG scores as instruments.

Column (1) of Table 6 presents the first-stage regression results using the average score of the local prefecture-level city as an instrumental variable. Weak identification tests, using the Cragg–Donald Wald F statistic, yielded a value of 10.280, which exceeds the Stock-Yogo 10% maximal IV size critical value of 9.38, indicating no issues with weak instruments. The underidentification test, using the Anderson canonical correlation LM statistic, reported a value of 9.915 with a Chi-sq (1) *p*-value of 0.0016, indicating no issues with underidentification. Additionally, the Sargan statistic for the overidentification test was 0.000, indicating that the model is exactly identified and that there is no evidence of overidentification, further confirming the validity of the selected instruments.

In Column (2) of Table 6, the second-stage regression provides an estimated coefficient for the ESG rating of 0.619, which is statistically significant at the 5% confidence level. This implies that, for each unit increase in the target firm's ESG rating, the TFP of its suppliers increases by 0.619. The IV-2SLS regression result, with an estimate of 0.447, is higher than the baseline estimate of 0.2361 shown in Column (2) of Table 4. This difference may be attributed to local treatment effects, but it still indicates the validity of the baseline estimate. These results offer robust insights into the relationship between firm ESG performance and TFP.

Table 6. IV-2SLS regression results.

Variables	(1)	(2)
	ESG	Customer TFP-OP
esgiv	−0.475 *** (−3.99)	
ESG		0.447 * (1.75)
grow_1	0.037 (0.79)	−0.311 *** (−3.88)
tobinq_1	−0.892 ** (−2.07)	4.069 *** (3.06)
cflow_1	0.287 (1.12)	1.733 (1.05)
roa_1	−0.060 (−0.33)	3.206 *** (5.90)
lev_1	0.113 * (1.89)	0.021 (0.14)
soe_1	0.026 (0.25)	0.447 * (1.75)
sepe_1	−0.014 (−0.79)	−0.080 (−0.57)
Observations	93	93
Province FE	Yes	Yes
Year FE	Yes	Yes

Notes: Figures in parentheses are standard robust criterion errors. ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.

4.3.2. Additional Control Variables and Control City-Fixed Effects

Table 7 incorporates additional control variables in the regression analysis to validate the baseline results and enhance the reliability of the study's findings. In Column (1) of Table 7, after supplementary control variables for the target firms were included, the coefficient related to ESG performance remains significantly positive at the 10% confidence level. In Column (2) of Table 7, provincial fixed effects were replaced with city-fixed effects to reduce the impact of omitted variable bias at the city level. The regression coefficient remains significantly positive. Notably, the estimated coefficient in Column (1) of Table 7 is 0.3738, and in Column (2), it is 0.2512. These coefficients are very close to the 0.2361 observed in the baseline regression, indicating the robustness of the baseline results and further supporting Hypothesis 1b.

Table 7. Regression results with additional control variables.

Variables	(1)	(2)
	Customer TFP-OP	Customer TFP-OP
ESG	0.3738 * (0.1954)	0.2512 * (0.1366)
grow_1	−0.2663 (0.1882)	−0.0670 (0.4529)

Table 7. Cont.

Variables	(1)	(2)
	Customer TFP-OP	Customer TFP-OP
tobinq_1	−0.3456 *** (0.0960)	−0.2706 * (0.1398)
cflow_1	2.3173 (1.5753)	2.3830 * (1.4148)
roa_1	5.3732 ** (2.6397)	6.0107 ** (2.5440)
lev_1	4.7067 *** (1.2091)	4.9038 *** (1.5292)
soe_1	−0.1002 (0.3847)	0.3431 (0.4221)
sepe_1	0.0226 (0.0271)	0.0010 (0.0447)
grow_2	−0.1995 (0.3439)	
tobinq_2	−2.3522 ** (0.9681)	
cflow_2	1.7093 * (0.9903)	
roa_2	0.7412 (0.6124)	
lev_2	−0.0385 (0.2389)	
soe_2	−0.0311 * (0.0164)	
sepe_2	0.3738 * (0.1954)	
Constant	3.7512 ** (1.5561)	3.9470 *** (0.9781)
Observations	93	93
Province FE	Yes	Yes
Year FE	Yes	Yes

Notes: Figures in parentheses are standard robust criterion errors. ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.

4.4. Robustness Stability Test

Table 8 presents the results of robustness checks conducted in the baseline regression analysis by replacing the dependent variables and adjusting the clustering of standard errors, ensuring the reliability of the study's findings. In Column (1) of Table 8, the LP method replaces the OP method to calculate the TFP of the target firm's customers (TFP-LP). In Column (2), the OLS method is used instead of the OP method to calculate supplier TFP (TFP-OLS). The regression coefficients in both Columns (1) and (2) are significantly positive, and they closely align with the values observed in the baseline regression, confirming the robustness of the results. In Column (3) of Table 8, the standard errors are clustered at

the firm level, and the regression results continue to show significant positive effects. The consistency of the baseline regression results is validated across Columns (1) to (3) through different methods of calculating dependent variables and varying standards for clustering standard errors. This cross-verification approach strengthens confidence in the findings and further demonstrates the positive impact of ESG performance on supply-chain efficiency.

Table 8. Robustness stability tests.

Variables	(1)	(2)	(3)
	Customer TFP-LP	Customer TFP-OLS	Customer TFP-OP
ESG	0.3786 ** (0.1696)	0.5057 ** (0.2119)	0.2361 (0.1644)
grow_1	−0.3811 ** (0.1683)	−0.4082 ** (0.1997)	−0.2591 * (0.1320)
tobinq_1	−0.3354 *** (0.1152)	−0.4042 *** (0.1339)	−0.2690 ** (0.1064)
cflow_1	3.0146 * (1.5447)	4.1042 ** (1.8572)	2.0559 (1.2374)
roa_1	6.7045 *** (2.4122)	7.4689 *** (2.6817)	5.9543 ** (2.2987)
lev_1	5.6299 *** (1.4036)	6.7625 *** (1.5996)	4.9567 ** (1.7411)
soe_1	0.2095 (0.4034)	0.3250 (0.4655)	0.3137 (0.3921)
sepe_1	0.0089 (0.0233)	0.0222 (0.0281)	0.0264 (0.0289)
Constant	0.3786 ** (0.1696)	0.5057 ** (0.2119)	0.2361 (0.1644)
Observations	93	93	93
Province FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Notes: ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively, with standard robust errors in parentheses.

5. Discussion

5.1. Research Contribution

In the current context, China's emphasis on green development and the SDGs, coupled with the challenges posed by the COVID-19 pandemic, underscores the importance of firms' ESG performance in enhancing supply-chain efficiency. While ESG factors may pose challenges to traditional profit maximization [21], this research—through the framework of vertical spillover theory [29]—demonstrates that ESG practices can enhance operational efficiencies and long-term value. This connection elucidates that ESG performance does not contradict the objective of profit maximization; rather, it expands this objective to encompass social and environmental dimensions. This study demonstrates that monopoly power diminishes efficiency and stifles innovation while hindering the dissemination of ESG-related externalities throughout the supply chain. By examining how market power moderates the relationship between ESG performance and supply-chain productivity, particularly in the context of sustainability efforts, this research contributes to the existing literature.

Compared to the existing literature, this study contributes in the following ways. First, while most existing research centers on the external effects of firm ESG performance on individual firms, this study explores these impacts through the lens of the automotive manufacturing supply chain [7,8]. The findings confirm that ESG performance has a direct impact on the firm and also influences its customers through relationships within the automotive manufacturing supply chain. This provides new insights and theoretical support for green supply-chain management research [44,55]. Second, this study demonstrates the role of firms' ESG performance in alleviating supply-chain financing constraints. This expands upon existing studies that mainly explore the financing benefits of a firm's own ESG performance. By showing how the ESG performance of target firms can reduce financing constraints for suppliers within the supply chain, this study enriches the theory of supply chain financing [56,57]. Third, based on the primary supply-chain relationships of the target firms, this study reveals that a firm's ESG performance enhances the TFP of its customers, rather than its suppliers, in the automotive manufacturing industry. In the automotive manufacturing industry in China, much of the technological innovation originates from upstream firms, providing significant benefits to downstream companies. Downstream firms often rely on the advanced technologies, components, and processes developed by their upstream suppliers to enhance their own production efficiency and product quality. This upstream-driven technological transfer plays a crucial role in enhancing the overall competitiveness and productivity of downstream firms. Moreover, this upstream-driven technological flow has accelerated the modernization and global competitiveness of China's automotive industry.

5.2. Comparison with Existing Literature

The conclusions of this study reveal the positive impact of a target firm's ESG performance on supply-chain management, consistent with existing research findings [3,58]. First, the baseline regression analysis demonstrates that target firms' ESG performance enhances the TFP of customers through vertical spillovers within the supply chain. These results align with studies on coordinating supply-chain development [59], and they expand on the concept of vertical spillover within the supply chain [60]. The demand for SDGs and the interdependence among supply-chain parties are two key factors driving the expansion of vertical spillover. Second, this study confirms the mediating role of target firms' ESG performance in facilitating financing, consistent with existing research, showing that ESG performance can alleviate financing constraints [61]. Target firms' ESG performance mitigates their own financing constraints and also extends benefits to customers through the supply chain. Additionally, the mechanism analysis reveals that a target firm's monopoly power in the automotive manufacturing industry negatively moderates the positive impact of its ESG performance on enhancing customers' TFP. This provides evidence that monopoly power can weaken the external effects of ESG performance, thereby undermining supply chain management [39].

5.3. Future Research

Understanding the limitations of this study is crucial for guiding future research efforts. First, although this study utilized empirical analysis methods and produced robust results, incorporating case studies could offer deeper insights into causal relationships and reveal more nuanced impact channels, leading to more actionable recommendations for supply chain management in the automotive manufacturing industry. Second, future research could explore how ESG performance and governance measures, including digital transformation, can jointly promote green supply chain management in the automotive manufacturing industry, offering a more comprehensive perspective on enhancing supply-chain sustainability.

6. Conclusions and Policy Recommendations

This study provides substantial empirical evidence demonstrating that superior ESG performance can enhance supply-chain efficiency and significantly impact the supply-chain management of target firms. Using a two-way, fixed-effects OLS model based on the Hausman test and a dataset spanning over a decade, the regression analysis shows that good ESG performance at target firms in the manufacturing sector positively influences the TFP of their customers. Mechanism analysis indicates that the ESG performance of target firms improves their customers' TFP by alleviating financing constraints. Furthermore, the positive effect of ESG performance on customers' TFP is moderated by the target firm's monopolistic power; the greater the monopolistic power, the weaker the ability of ESG performance to enhance TFP. The validity of the baseline regression results was confirmed through IV-2SLS endogenous analysis and the inclusion of control variables. A series of robustness tests were consistent with the baseline regression results.

Based on the research findings, this study proposes the following policy recommendations. First, local governments should offer tax breaks and subsidies to encourage ESG practices in the automotive manufacturing industry, helping to strengthen environmental sustainability and supply-chain resilience. Second, governments should support the development of specialized industrial clusters in automotive manufacturing, fostering collaboration and innovation within the supply chain to reduce monopolistic influences and promote green practices. Third, governments should prioritize suppliers with strong ESG performance in public procurement, setting an example for the broader market to follow. Fourth, financial institutions should create green bonds and sustainable funds to provide affordable financing to firms, reducing financial constraints and encouraging ESG adoption. These recommendations aim to create an environment favorable to ESG investment, strengthen automotive manufacturing supply-chain management, and promote sustainable practices throughout the supply chain.

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